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AUTHOR Mackovak, William P.
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ABSTRACT

The purpose of this study was to demonstrate a methodology which could be used to estimate the reading skills of Air Force personnel and the reading requirements of different career fields in an attempt to determine the extent of the difference between the reading skills of personnel and the reading requirements of the training materials in a given field. Methodologies for determining levels of reading in career fields were reviewed, as were readability measures which could serve as integral parts of reading requirements methodologies. The most desirable methodology had to be objective, valid, inexpensive and easy to apply, and not overly time consuming. The methodology decided upon involved the application of a readability formula to random samples of reading materials taken from five technical courses at Lowry Air Force Base. The Forecast formula was selected as the readability measure. The results indicated that the methodology selected could be applied quite easily to entire Air Force career fields; once the representative sample of reading material has been collected, it is an easy matter to determine readability; and the Forcast formula appears to have the greatest potential for use in the field. (WR)

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AIR FORCE HUMAN RESOURCES LABORATORY

AN INVESTIGATION AND DEMONSTRATION OF METHODOLOGIES FOR DETERMINING THE READING SKILLS AND REQUIREMENTS OF AIR FORCE CAREER LADDERS

By

William P. Mockovak, Capt, USAF

TECHNICAL TRAINING DIVISION
Lowry Air Force Base, Colorado 80230

January 1974

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MARTY R. ROCKWAY, Technical Director
Technical Training Division

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This report investigates alternative approaches or methodologies that could be used to determine the reading skills and requirements of Air Force career specialties. Several of the methodologies reviewed have actually been applied in Army military occupational specialties, but the purpose of this study was to select and demonstrate a methodology which had the greatest potential for use within the Air Force. The methodology selected in this effort was applied to five technical courses at Lowry AFB, resulting in empirically determined reading requirement levels for those courses. A comparison of two methods used for predicting an individual's reading grade level from standarized test measures of general ability was also accomplished.

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Summary

Problem

Although numerous complaints have been received from the field concerning reading problems, the Air Force has not had an easy and inexpensive method of determining if the problems were the result of inadequate reading skills of personnel, difficult training materials, or a combination of both factors. The purpose of this study was to demonstrate a methodology which could be used to estimate the reading skills of personnel and the reading requirements of different career fields in an effort to determine the extent of the "literacy gap," or the difference between the reading skills of personnel and the reading requirements of the training materials in a given career field.

Approach

A review of the literature on methodologies, that could be used to determine the reading skills and requirements of Air Force career ladders, revealed approaches that were easily adaptable to the research needs of the Air Force. One such method was chosen and demonstrated in five technical courses at Lowry AFB, which represented a diverse range of aptitude levels and content material. This methodology consisted of two basic parts: (1) a readability analysis of the training material that was accomplished using the FORCAST readability formula, and (2) estimates of trainees' reading grade levels using either AQE or AFQT data. In addition, a standardized reading test was administered to trainees in order to determine the relative accuracy of the AQE or AFQT approaches in estimating reading ability.

Results

The demonstration of the methodology in the five technical courses revealed that it was inexpensive and relatively easy to apply. Furthermore, the approach produced significantly different reading requirement levels for the disparate career fields. It should be noted, however, that a monotonic relationship between course content difficulty and reading requirement levels was not obtained. On the contrary, the courses with the lower aptitude personnel had the highest reading requirement levels and therefore the largest "literacy gap." The comparison of techniques for estimating reading grade level from AQE or AFQT scores indicated that the Madden and Tupes (1966) procedure using AQE data produced the most accurate estimates using group data.

Conclusions

A methodology for determining the reading skills and requirements of Air Force career fields was demonstrated, which could easily be applied throughout all Air Force career fields. The methodology is simple to apply and inexpensive, but it can also be relatively time-consuming and monotonous. Nevertheless, it significantly discriminates between the reading requirements of different career fields. In the event that reading problems occur in a career field, a methodology was shown to exist whereby the Air Force can determine whether the problem lies in the training material, in the abilities of the trainee, or in both places.

PREFACE

This report was written in response to RPR 72-35, Determining Reading Skills and Requirements of Air Force Career Ladders. It is the first in a series of reports dealing with the Air Force's reading problems and long term solutions to those problems. The author gratefully acknowledges the assistance of Dr Ronald Burkett, Maj Philip DeLeo, and Dr Marty Rockway in the preparation of this paper.

TABLE OF CONTENTS

		Page
I.	Introduction	5
	Methodologies for Determining the Reading Skills and Requirements of Air Force Career Ladders	5
	Demonstration of a Methodology for Determining the Reading Skills and Requirements of Air Force Technical Courses	10
	Applications to Air Force Career Fields and Conclusions	18
	Recommendations for Dealing with Reading Problems in the Air Force	18
References		20

LIST OF ILLUSTRATIONS

Figure		Page
1	Percent of Post CTS Men at Each Reading Grade Level Scoring 70% or Higher Correct on the Job Reading Task Tests for Three MOS. Borrowed from Sticht *et. al.* (1971)	7

LIST OF TABLES

Table		Page
1	Distribution of Trainee RGLs	12
2	Distribution of Sample Readability Levels	12
3	Distribution of Trainee RGLs	13
4	Distribution of Sample Readability Levels	13
5	Distribution of Trainee RGLs	14
6	Distribution of Sample Readability Levels	14
7	Distribution of Trainee RGLs	15
8	Distribution of Sample Readability Levels	15
9	Distribution of Trainee RGLs	16
10	Distribution of Sample Readability Levels	17
11	Reading Requirement Levels of the Technical Courses	17
12	Comparison Between Madden and Tupes and Caylor Average RGL Estimates for the Technical Courses	18

AN INVESTIGATION AND DEMONSTRATION OF METHODOLOGIES FOR DETERMINING THE READING SKILLS AND REQUIREMENTS OF AIR FORCE CAREER LADDERS

I. INTRODUCTION

There are several factors (intelligence, motivation, socio-economic background, need for achievement, attitudes, etc.) that, in part, can help explain technical school performance, as well as future job proficiency. Reading, or literacy skill, is only one such variable; yet intuitively, it demands emphasis because it is the primary means by which information is acquired in our technological society. In a recent investigation of Army military specialties, Sticht, Caylor, and Kern (1971) discovered that reading ability was related to job proficiency using three different criteria of job proficiency: reading task tests, job performance tests, and job knowledge tests. Even more interesting, however, was the finding that if reading materials were too difficult, men tended not to use them. Also, the greater a man's reading ability, the more likely he was to use printed materials, even if they were difficult.

In October 1966, the Department of Defense initiated a program called Project 100,000. Under this program the military services began accepting men who otherwise would have been rejected because of certain physical characteristics (overweight, etc.), or because of unacceptable scores on the Armed Forces Qualification Test (AFQT). It was hoped that these "new standards" men would be able to obtain educational and other benefits from a military career, but their entry into the service also posed certain training problems. Out of 46,000 Project 100,000 men given reading tests, 31 percent read below a fourth grade level, and 68 percent read below a sixth grade level. The possibility exists that under an all-volunteer force concept, the qualifications and education of incoming manpower might diminish, and although the levels reached are not expected to be as low as the Project 100,000 data, nonetheless, such figures are indicative of the training problems that might occur if there is a dramatic drop in the skill levels of military enlistees. There appears to be ample justification, therefore, to merit an investigation of reading skills as a determinant of satisfactory job performance.

Sticht *et al.*, (1971) defined the literacy requirement of a job as "the minimum level competency associated with a specified level of satisfactory job proficiency," but actually specifying this competency level empirically is a complex problem which highlights the inadequacies of current measuring instruments and empirical approaches. For example, it would be ideal in the Air Force if, based on different content areas, it could be possible to specify "optimal" readability requirement levels for different career fields irrespective of student input. Logically, this would seem possible since it appears that a highly complex technical area would require a higher reading requirement than mere vehicle operation, for example, However, practically speaking, the reading requirement level for any job is really a flexible figure which can be raised or lowered through job design. The important determinant is the trainee population for which the material is being prepared, since even an "optimal" reading requirement level infers the existence of a trainee population (having certain measurable characteristics) for which the training literature would be maximally comprehensible.

This report approaches the problem of determining reading requirement levels through a procedure which utilizes the actual training materials of different career fields to arrive at a reading requirement level which can then be compared with the reading abilities of trainees in those career fields. However, other purposes of this paper are to: (1) investigate those methodologies for determining the reading skills and requirements of job specialities that have the greatest applicability in an Air Force context, and (2) apply a selected methodology to a spectrum of Air Force career fields in order to determine its feasibility, problems of application, and potential uses for selection and training. This report will deal only with an analysis of technical course reading requirements; however, the methodologies investigated are just as applicable to job reading materials with only minor modifications in application procedures.

Methodologies for Determining the Reading Skills and Requirements of Air Force Career Ladders

In the context of this report, a methodology is viewed as a systematic procedure which may involve testing or an analysis of reading materials, student records, etc. It may be very time-consuming and complex, or simple and straightforward, but the methodologies to be reviewed are those which appear to have the greatest practical benefit and applicability within the Air Force, and the criteria on which they will be evaluated are: (1) objectivity, (2) validity, (3) ease of application, (4) preparation costs, and (5) time

constraints. In the following sections, several such methodologies for determining reading requirements are presented. A discussion of their relative strengths and weaknesses with respect to the above criteria is also included.

Job Reading Task Tests. Sticht *et al.*, (1971) developed the use of Job Reading Task Tests (JRTT) to determine the reading requirements of four Army military occupational specialties (MOS). The basic assumption in using this approach is that the reading ability requirements of a job can best be described as that ability necessary to perform the day-to-day reading tasks of that job. Of all the methodologies to be discussed, this approach involves the most direct assessment of the ability to read and understand job reading materials because actual job reading tasks are employed. The procedure followed in applying this methodology involves, first of all, a determination of those reading tasks crucial to successful job performance. This can be accomplished in several ways (observation, asking course experts, etc.), but Sticht *et al.*, (1971) accomplished this by means of a structured interview of job incumbents. The job reading tasks discovered in the interviews then were combined to form a Job Reading Task Test, which covered a variety of reading tasks and content areas, ranging from the use of table of contents and following procedural directions, to acquiring information from functional descriptions.

Performance on the JRTT essentially serves as an index of job reading proficiency; therefore, if one measures the reading ability of a group of men in a job area, and then their subsequent performance on the JRTT, it is possible to establish literacy requirements for a job. For example (Figure 1), if one adopts a decision rule such that 80 percent of the men in a job must score 70 percent or higher on the JRTT, then it is possible to establish a reading requirement level for a job by finding that reading grade level (RGL), as measured by a standardized reading test, at which 80 percent of the men score 70 percent on the JRTT. This procedure is demonstrated in Figure 1 by the dotted line and it yields reading requirement levels of 7, 7.9, and 10 for the repairman, cook, and supply clerk MOSs, respectively. It should be emphasized that the 80/70 decision rule is an arbitrary choice which is dependent on such factors as quantity and quality of trainee input. It must be the responsibility of military decision makers to decide upon the exact parameters of this decision rule, and hence how stringent, the reading requirement level should be.

The primary advantage of the JRTT methodology, as stated earlier, is that it is a direct measure of those reading skills necessary to perform effectively on job reading tasks. Besides its intuitive appeal and acceptable reliability (0.74 - 0.85), the approach also serves to discriminate between those reading skills important to the job. Therefore, it has potential use as a diagnostic tool which can isolate weak skill areas and specify the type of remedial training necessary.

The biggest disadvantage of the JRTT methodology is the preparation/administration time and expense required to construct a JRTT for a given job. It is also difficult at times to specify exactly what job reading material should be included in the JRTT since Sticht *et al.*, (1971) found disagreement between supervisors and job incumbents over what materials were actually being used to do the job. There is also serious question as to whether or not construction of a JRTT is worth the effort, since Armed Forces Qualification Test (AFQT) scores and standardized reading test scores (USAFI Ach Test III), were equally as effective as the JRTT in predicting academic achievement in Army MOS training. Again, literacy skills are only one of several potential factors affecting total job performance. Finally, the reading requirement level obtained by the JRTT methodology is a flexible figure manipulable by decision makers. The JRTT approach, therefore, is not feasible for use with individual career fields unless there are over-riding reasons for expending the necessary preparation time and money. The JRTT's greatest potential use appears to be with clusters of related career fields, where it can serve as a useful diagnostic tool.

Besides determining the relationship between the performance of job incumbents on a standardized reading test and a measure of job proficiency like the JRTT, other measures of job proficiency such as job knowledge paper-and-pencil tests, job performance tasks, and supervisor ratings have also been used (Sticht *et al.*, 1971). Supervisor ratings, however, may not validly reflect job proficiency and the other approaches suffer from the same disadvantages as the JRTT; that is, they are too prohibitive in terms of the time and money required to apply the procedure. Caylor, Sticht, Fox, and Ford (1973) determined the correlation between estimated reading ability (estimated from AFQT data) and job proficiency as measured by the Army Primary Occupational Specialty/Evaluation Test (MOS/ET) and Enlisted Effectiveness Rating (EER), and found that the EER could not be used to estimate the reading demands of a job; however, the MOS/ET was a possibility. Obviously, the Air Force has its counterparts in the Airman Performance Reports and scores on the Weighted Airman Promotion System (WAPS), and the use of MOS/ET scores (or WAPS scores

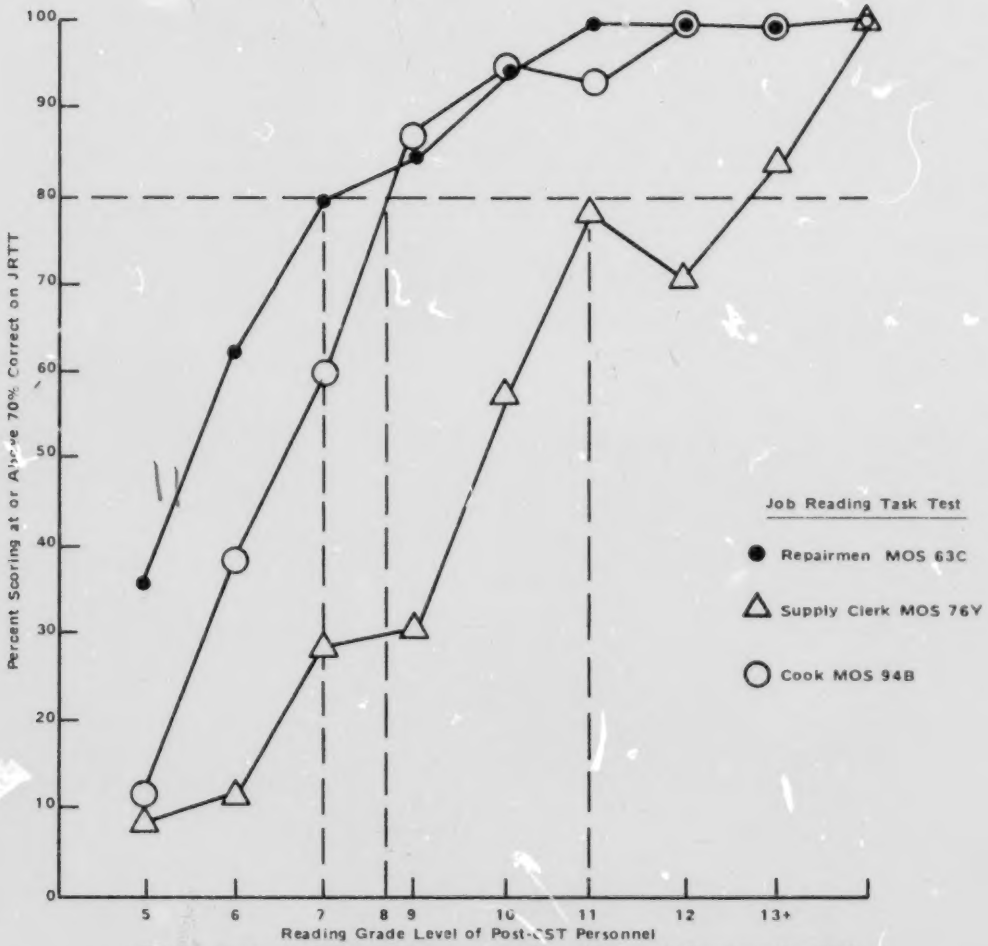

Fig. 1. Percent of Post-CTS men at each reading grade level scoring 70% or higher correct on the Job Reading Task Tests for three MOS. Borrowed from Sticht *et. al.* (1971).

in the Air Force), although a very convenient and easy methodology for determining reading requirements is really only an indirect measure of reading requirements, since many other factors enter into performance on the tests. Therefore, this methodology is not suggested for use in the Air Force.

Measures of Readability. The use of readability formulas as a part of a methodology for determining reading skills and requirements is an appealing approach because such formulas are generally easy to use and therefore not very demanding in terms of preparation and administration costs. Some of them, however, are very monotonous and laborious and not all are applicable within the context of Air Force technical training. When referring to readability measures, readability is intended to indicate how easy the material is to read and comprehend. Although the term is easy to define, it offers innumerable problems when one attempts to quantify it, since readability is affected by such things as sentence length, vocabulary, writer's style, syntactic structure, and the reader's interests and prior knowledges. Traditional readability formulas have relied basically on structural features like average word length, average sentence length, and other quantifiable factors, such as frequency of occurrence of common words, phrases, clauses, etc. Lautman, Siegel, and Williams (1973) list 45 readability formulas that have been developed since 1923 with the Flesch and Dale-Chall formulas being the most widely known and used. Although readability formulas have been used to a large extent in the past and present, there are inherent dangers in their use. For one thing, while they may be related to readability, they were never meant to be a guide for effective writing. Merely shortening sentences and using smaller words will not guarantee a good writer. Also, the applicability of readability formulas is dependent to a large extent on the backgrounds of the persons in a field. For example, a book on nuclear fission theory might have a ninth reading grade level, but a poet may not think so. The point to be emphasized is that readability formulas should be used with caution and an awareness of their limitations-they definitely are not foolproof. However, they can be used as part of a methodology for determining the reading requirements of a job. The steps in such a methodology involve: (1) a determination of what reading materials are necessary for successful job performance, and (2) application of the readability formula to a representative sample of these job reading materials. It is then an easy step to determine the average reading grade level at which the materials are written.

In the following section, those readability formulas and measures having the greatest applicability in the Air Force environment will be discussed along with their unique strengths and weaknesses.

The FOG Count, Cloze Technique and Associated Readability Measures. The FOG count is the most widely used readability formula in the Air Force (AFP 10-1). It is closely related to the Flesch formula because it also is dependent on a syllable count. However, no statistical information relating to its development or accuracy is available (Lautman *et al.*, 1973). It is also relatively easy to use, a value of 1 is assigned to each word of one or two syllables appearing in a sample passage, and a value of 3 to each of the remaining words which have 3 or more syllables. The actual sentences comprising a sample passage are dependent on an algorithm described fully in AFP 10-1. To determine the reading grade level (RGL) for passage, the assigned values are added resulting in the FOG count. If this sum is greater than 20, it is divided by 2 to obtain a RGL. If the FOG count is less than 20, 2 is subtracted, and the new total is divided by 2.

The FOG count is an objective measure which is inexpensive to use; however, it is time consuming and its reliability does not meet accepted levels. Huff and Smith (1970) found test-retest reliability coefficients between 0.49 and 0.56 when the FOG count was used on the same material.

As mentioned previously, other readability formulas (e.g., Flesch, 1948) have gained wider acceptance and use than the FOG count, but such formulas are relatively time consuming and require manual operation which is a serious deficiency when the voluminous amounts of Air Force written materials are considered.

Another related approach, though not strictly a readability formula, is the Cloze technique developed by Taylor (1953). This technique involves taking samples of text and presenting them to subjects with words deleted, generally every fifth word in the sample. It is the subject's task to fill in the correct words and his comprehension of the passage is indicated by the percentage of omitted words which he correctly provides.

The advantages of this technique are that it can handle stylistic differences of authors, the scoring is objective and reliable, it accounts for interest and prior knowledge of the reader population, and its validity is comparable to that of the Flesch and Dale-Chall formulas. Moreover, subjects of all abilities seem to enjoy it, and it is easy to construct test materials; all that is necessary is to delete every fifth word which

can be handled quite easily by a machine. However, although the Cloze technique has been widely used in experimental contexts, it would be extremely difficult to adapt it as part of a methodology for determining reading requirements since it is expensive and time consuming. Another disadvantage of the Cloze technique is that it is only a measure, not a predictor of readability. That is, the readability of a passage can be assessed only after large samples of people have been tested on the passage or passages. Needless to say, this could not be accomplished for the vast amounts of reading materials in Air Force career fields. Also, there are theoretical criticisms of the Cloze technique which argue that the Cloze score may not accurately reflect all varieties of comprehension, that it may depend more on knowledge of language than subject matter, and finally, there seems to be an extensive dependence on "short-range" constraints; that is, the four or five words appearing on each side of the deleted word (Lautman *et al.*, 1973). Due to these limitations, it is not feasible to use the Cloze technique as part of a reading requirement methodology. Its primary uses will probably continue to remain within an experimental context.

The Automated Readability Index (ARI). The Automated Readability Index, like traditional readability formulas, is based on measures of average sentence length (words per sentence) and average word length (strokes per word). It was developed by Smith and Senter (1967), to relieve the monotony, boredom, and clerical work associated with other readability formulas. The most appealing aspect of the ARI is that it is completely automated, except for the final ARI calculation (Young, 1972), which means that a typist can collect all the necessary data because impulses from the typewriter activate counters which record the number of letters, words, and sentences contained in the passage. The ARI index can be obtained from the formula:

where $ARI = (w/s) + 9\,(s/w)$

w/s = words per sentence

s/w = strokes per word

Another advantage of the ARI is that it is extremely reliable, and since it is so easy to use, reliability can be increased merely by increasing the number of pages sampled. Smith and Senter estimated the reliability or correlation between two different 5 page samples to be 0.46 for word length ratio, 0.81 for sentence length, and 0.91 for the ARI index. For 10 page samples, these figures increased to 0.87, 0.92, and 0.95, respectively. Of course, as was noted in the same report, the imperfect reliability reflects variations in the material being sampled. Tabulations based on the same material would approach a reliability coefficient of 1.0. (Huff & Smith, 1970). The usefulness of the ARI has also been demonstrated with Career Development Course (CDC) material (Huff & Smith, 1970), where baseline data was provided for 20 CDCs, and with Air Force technical orders (Kincaid, Yasutake, & Geiselhart, 1967), where it was shown that the ARI index was sensitive to different difficulty levels of technical materials. It is also interesting to note that in this same study, the ARI correlated -0.90 with the Flesch index and 0.79 with the FOG count. (A higher Flesch score indicates easier material, whereas, a higher ARI and FOG count indicate harder materials.)

In summary then, the ARI could easily be used in a methodology to determine the reading requirements of Air Force career fields. Almost all manuscripts produced in the Air Force require retyping at one point or another, and by means of a simple attachment to an electric typewriter, readability measures can be taken in a matter of seconds to insure that the materials are not overly difficult for the population for which they are being written. The ARI does have the capability of being computerized, but most importantly, it relieves the boredom and montony associated with manual counts of structural features to determine readability. The disadvantages of the ARI are that it requires a special mechanical attachment, which may not be readily available at all manuscript preparation points in the Air Force. Also, the ARI gives valid reading grade level equivalents for material only through the seventh grade. Above that level, written materials can be ranked in terms of difficulty, but any conversion to RGLs is based on extrapolation and should, therefore, be interpreted with caution. (Almost all readability formulas, however, are subject to this limitation.) The use of the ARI also assumes narrative material and not segmented material like check lists, operating instructions, etc. Despite these limitations, however, the ARI is still extremely useful. Compared to the FOG count; for example, it has far greater reliability; it is possible to take larger samples; it provides a hard copy for data verification; and it relieves the technical writer from the boring task of data collection. The ARI's most likely point of implementation would be at centralized manuscript preparation points within the Air Force.

The FORCAST Formula. The Forcast formula was developed by Caylor *et al.*, (1973) for use in a methodology to determine the reading requirements of Army MOSs. The unique aspect of the FORCAST formula is that it was developed using Army training literature and normed for a population of young adult Army personnel. Its development, therefore, contrasts sharply with other readability formulas which have usually been developed using standard reading passages such as the McCall and Crabbs (1925), and then normed using school children as subjects. The formula itself, is based on a count of the number of one syllable words in a 150 word sample. It has high correlations with the Flesch and Dale-Chall formulas (Caylor *et al.*, 1973) of 0.92 and 0.94, respectively. However, it is much simpler to use. The general limitations of the FORCAST formula are that it cannot estimate readability levels below 5 and estimates above 12.9 are based on linear extrapolation. Also, use of the formula can become monotonous and time consuming, but next to the ARI, it is the easiest readability formula to use and the fact that it was developed with Army technical material should justify its use with Air Force technical material.

$$RGL = 20 - \frac{\text{Number of 1 syllable words}}{10}$$

where RGL = reading grade level

As mentioned previously, the FORCAST formula can be easily adapted for use in a methodology to determine reading requirements. It is inexpensive, it can be used by anyone at any location, and it can be used with a single paragraph (150 words or more), a sample of material, or even an entire career field.

Demonstration of a Methodology for Determining the Reading Skills and Requirements of Air Force Technical Courses

In previous sections, actual methodologies for determining reading requirements of career fields have been reviewed, as well as techniques (readability measures) which can serve as integral parts of reading requirements methodologies. The unique strengths and weaknesses of these various approaches have been discussed. The purpose of this section is to select what appears to be the most desirable methodology for use in the Air Force. Once again, the methodology was chosen to satisfy the following criteria, it must be: (1) objective, (2) valid, (3) inexpensive and easy to apply, and (4) not overly time consuming.

The methodology decided upon in this study involved the application of a readability formula to random samples of reading materials taken from five technical courses at Lowry AFB. The FORCAST formula was selected as the readability measure in this study because it was previously used with military training literature in Army MOSs, it has an effective range of 5 - 12.9, it is easy to use, and compared to most formulas, it requires little computation time. It also appeared to be the most likely manual substitute for the FOG count currently used in the Air Force.

One of the goals of the present study was to establish the reading requirements of five technical courses at Lowry AFB, the Weapons Mechanic Course (WM), 3ABR46230-2, the Nuclear Weapons Specialist Course (NWS), 3ABR46330, the Precision Measurement Specialist Course, 3ABR32430-2, the Inventory Management Course (IM), 3ABR 64530-1, and the Maintenance Electronics Course (ME), 3AQR40020. These courses were selected because they represent a wide range of content areas, as well as different student input. In addition to determining the reading requirement levels of the different courses, another goal was to determine the reading ability distributions of the students in each of the technical courses in an effort to determine if the reading requirements of the courses were excessive compared to the literacy levels of the students in them. Where it was possible, data were also collected on student achievement in the courses, in order to determine the relationship between student performance and reading ability levels.

Description of the Procedure. The actual reading materials used in the technical courses were collected and random, narrative samples (150 words) for each course were generated in order to represent, as much as possible, the different areas of emphasis within the course, such as operation of equipment, description, maintenance, safety, troubleshooting instructions, etc. The number of samples taken within a course depended on the amount of narrative material available, but the general guideline used was that a course consisting of 4 blocks required about 30 samples; whereas, 8-12 block courses required 40-60

samples. MIL-M-6300B (TM), Amendment 2, 25 Jan 69, describes firmer guidelines, but for the purposes of this study, sampling was discontinued once the mean reading grade level appeared to level off.

Samples of students (40-84 students) were also given Part II of the USAFI Achievement Test III (UAT III), in an effort to determine their actual reading grade levels (RGLs). The only exception to this procedure occurred in the IM Course, where Part I (Word Knowledge) was used instead. The IM vocabulary scores were converted to estimated RGLs using a regression equation, since there is a high correlation (0.82) between reading scores and vocabulary scores on the UAT III.

Since large scale reading testing would be prohibitive within the Air Force, alternative means were investigated for estimating the RGLs of trainees from standardized test scores available on their training records (ATC Form 156). The two procedures compared were the Madden and Tupes (1966) regression equations and the Caylor *et al.*, (1973) regression equation. These two approaches rely on AQE scores and AFQT scores, respectively, to arrive at a determination of RGL.

Results. The results of the readability analyses and reading testing are presented in Tables 1 through 11. As mentioned previously, it was hoped that further large scale reading testing of trainees could be avoided if an accurate estimate could be obtained from standard test scores maintained in Air Force data banks. The Madden and Tupes Gen AQE conversion tables have been used before by the Air Force to determine which airmen should be given a reading test when entering into on-the-job training (AFM 50-23), but for the purposes of this study, the more exact regression equations utilizing selector Aptitude Indexes (AIs) unique to career fields were used. The Caylor *et al.*, (1973) regression equation is based on the AFQT score of an individual, that is,

$$\text{Estimated USAFI Ach Test III RGL} = 0.75\ \text{AFQT} + 5.52$$

It was expected that the Caylor equation would be a better predictor because the equation was developed using the UAT III; whereas, the Madden and Tupes procedure was based on RGLs obtained from the California Achievement Test, Form W. The validity of the Madden and Tupes formulas with present Air Force manpower has recently been reaffirmed (Lautman *et al.*, 1973).

Tables 1 and 2 contain the relevant information obtained from the NWS course. It is possible with the two tables to compare the distribution of trainee reading abilities with the distribution of sample readability levels. The mean tested RGL of the trainees in the NWS course was 11.8 (Table 1). Referring to Table 2, it can be seen that approximately 95 percent of the NWS training literature sampled was written below that level. In Table 2, there are two estimates of the reading requirement level of the NWS course. The 75 percent Decision Rule (75 DR) is that point (RGL) on the cumulative readability distribution below which 75 percent of the sample passages analyzed were written, and it is based on a conclusion by Bormuth (1968) that a comprehension test score of 75 percent is necessary for effective study of a text with a teacher present. The 75 percent Decision Rule suggests only that a trainee with that RGL will be able to read and comprehend 75 percent of the material in a course without the instructor's help, not that he would be able to score a 75 percent on a comprehension test of the material. However, as is apparent in Tables 2 through 10, the 75 DR yields reasonable readability requirement estimates for the different courses. This decision rule can, of course, be modified, but it should be emphasized that there are many redundant sources of information in Air Force technical courses, such that the 75 DR may actually be more stringent than necessary. Therefore, with the assumption that a student should be able to read and understand 75 percent of the written material in a course with an instructor present, the 75 DR yields a reading requirement level for the NWS course of 11.3 which is surpassed by 85 percent of the trainees in the course.

The Air Force, for each of its career fields, has established selector AQEs which hopefully will provide personnel with those skills necessary for job success. One such selector aptitude index (AI), the General AQE, is in fact, a partial measure of reading ability. Therefore, in a very real sense, when the Air Force establishes a Gen AQE cut-off, it is also indirectly establishing a reading requirement level which can be estimated by using the proper Madden and Tupes (M-T) regression equation. In the NWS course, the selector AIs were a Gen AQE of 70 and an Elec AQE of 70, which yield a reading requirement estimate of 11.3 (RGL = 0.0743 Gen AI + 0.0222 Elec AI + 4.6088). In this case, there was close agreement between the 75DR and the M-T estimate of 11.4, so the current Air Force selector AIs adequately account for the

Table 1. **Distribution of Trainee RGLs**

(Nuclear Weapons Specialist 3ABR 46330)

RGL	Number of Trainees	Percent	Cumulative %
12.9	5	12	12
12.5	6	15	27
12.2	10	24	51
11.9	8	20	71
11.7	3	7	78
11.6	3	7	85
11.2	2	5	90
10.8	1	2	92
10.3	1	2	95
9.9	2	5	100

$N = 41$

UAT III Mean	= 11.8, s.d.	= 0.8
Madden and Tupes Mean Est	= 12.2, s.d.	= .94
Caylor Mean Est	= 11.6, s.d.	= 1.0
Selector AIs: Elect AQE - 70		
and Gen AQE - 70		

reading requirements in the NWS course. In Table 1, it is interesting to compare the M-T's mean RGL estimate with the Caylor mean RGL estimate and the actual tested UAT III mean RGL for the technical course. In this case, the Caylor equation was a slightly better indicator (11.6 vs 12.2) than the M-T equation of the trainees' average reading grade level.

Table 2. **Distribution of Sample Readability Levels**

(Nuclear Weapons Specialist)

Readability (RGL)	Number of Samples	Percent	Cumulative %
12+	2	5	5
11-11.9	15	35	40
10-10.9	18	42	82
9- 9.9	5	11	93
8- 8.9	3	7	100

$N = 43$

Mean Readability Level	= 10.7
75 Percent Decision Rule	= 11.3
Madden and Tupes Reading Rq Est	= 11.4

Referring to Tables 3 and 4, the mean tested RGL of the trainees in the WM's course was 10.7 which is identical with the M-T's mean RGL estimate. The Caylor estimate of 9.9 was almost an entire grade level too low. The reading requirement of the WM course using the 75 DR was 12.1 which means that roughly 90 percent of the trainees in WM might experience difficulty reading the necessary materials. The M-T reading requirement estimate of 9.6 (based on Mech or Elec AQE of 60, and averaged Gen AQE for trainees in sample) is unrealistically low, because 94 percent of the samples taken were written above this level, but it is due to the fact that no Gen AI selector is specified for the course. Had a Gen AI been specified, it would take a Gen AI of 75, in addition to the Mech or Elec AIs of 60, in order to meet the reading requirement of 12.1. Obviously, the materials are written at too difficult a level, especially in light of the fact that 12 percent of the trainees tested read below a ninth grade level.

Table 3. **Distribution of Trainee RGLs**
(Weapons Mechanic 3ABR 46230-2)

RGL	Number of Trainees	Percent	Cumulative %
12.5	3	6	6
12.2	3	6	12
11.9	4	8	20
11.7	4	8	28
11.6	5	10	38
11.2	10	21	59
10.8	1	2	61
10.3	6	12	73
9.9	6	12	85
9.7	1	2	87
8.5	1	2	89
8.3	3	6	95
6.8	1	3	98
5.7	1	2	100

$N = 49$

UAT III Mean	= 10.7, s.d.	= 1.5
Madden and Tupes Mean Est	= 10.7, s.d.	= 1.4
Caylor Mean Est	= 9.9, s.d.	= 1.4
Selector AIs Mech AQE	- 60	
or Elect AQE	- 60	

It should be noted at this time that in both the NWS and WM courses, a great deal of the reading material is contained in technical orders which for the most part are procedural and check-list in nature. There is a limited amount of narrative material to which the FORCAST formula is applicable; therefore, the technical orders were not included in the sample which may lower or raise the reading requirement levels of the respective courses. A limited sample (N=13) of material was taken from the WM's TOs and an average readability level of 12 was obtained, which indicates that the reading requirement level of the WM course might even be raised if the TOs were included in the samples.

Table 4. **Distribution of Sample Readability Levels**
(Weapons Mechanic)

Readability (RGL)	Number of Samples	Percent	Cumulative %
14+	1	2	2
13-13.9	2	4	6
12-12.9	12	24	30
11-11.9	21	42	72
10-10.9	11	22	94
9- 9.9	3	6	100

$N = 50$

Mean Readability Level	= 11.4
75 Percent Decision Rule	= 12.1
Madden and Tupes Reading Rq Est	= 9.6

Tables 5 and 6 contain the relevant data for the ME course. The UAT III mean was 12.1 and a 75 DR reading requirement of 11.5 was obtained which is surpassed by approximately 87 percent of the trainees in the course. The M-T's reading requirement estimate was 11.2 which is an insignificant difference from the 75 DR. Once again the current Air Force AQE cut-off scores are adequate enough to account for the

Table 5. **Distribution of Trainee RGLs**
(Maintenance Electronics 3AQR 40020)

RGL	Number of Trainees	Percent	Cumulative %
12.9	5	12	12
12.5	8	20	32
12.2	10	25	57
11.9	5	13	70
11.7	7	17	87
11.6	3	8	95
11.2	1	3	98
10.3	1	2	100

$N = 40$

UAT III Mean = 12.1
Madden and Tupes Mean Est = *
Caylor Mean Est = *

Selector AIs Elec AQE - 70
and Gen AQE - 70 or Elec - 80

*Data not available for necessary calculations.

reading requirement of the ME course. Unfortunately, individual AQE data for the students were not available; therefore, the comparative accuracy of either the M-T or Caylor formulas for estimating the average RGL of the students in this course could not be determined.

Table 6. Distribution of Sample Readability Levels
(Maintenance Electronics 3 AQR 40020)

Readability (RGL)	Number of Samples	Percent	Cumulative %
12-12.9	5	8.3	8.3
11-11.9	24	40.0	48.3
10-10.9	25	41.6	89.9
9- 9.9	6	10.1	100

$N = 60$

Mean Readability Level = 11.0
75 Percent Decision Rule = 11.5
Madden and Tupes Reading Rq Est = 11.3

The IM course (Tables 7 and 8) had a UAT III mean RGL of 11.3 which was identical to the M-T estimate of the average RGL for the sample of trainees. The Caylor estimate was significantly lower (1.6 grade levels). The reading requirement of the course using the 75 DR is 12.1 which means that approximately 90 percent of the trainee input tested read below this level. The M-T's reading requirement estimate using current Air Force selector AIs (average Gen AQE in the sample data was used in the M-T's

Table 7. **Distribution of Trainee RGLs**
(Inventory Management 3ABR 645x0-1)

RGL	Number of Trainees	Percent	Cumulative %
12.3	4	10	10
12.0	3	7	17
11.8	6	15	32
11.5	5	13	45
11.2	3	7	52
10.8	3	8	60
10.4	2	5	65
10.2	2	5	70
9.9	1	2	72
9.6	4	10	82
9.3	3	8	90
8.9	1	2	92
8.6	1	3	95
7.5	1	2	97
5.7	1	3	100

$N = 40$

UAT III Mean	= 11.3, s.d.	= 1.4
Madden and Tupes Mean Est	= 11.3, s.d.	= .95
Caylor Mean Est	= 9.7, s.d.	= 1.3
Selector AIs Gen AQE or Admin AQE	- 60 - 60	

formula) was 10.6 even though less than 25 percent of the materials were written below this level. Again, the shortcoming of this estimate lies in the AQE cut-offs which have been established for the course. Three solutions present themselves; the selector AIs can be raised or changed until the reading requirement is met, the reading requirement level of the material can be lowered through modification, or supplemental and redundant presentation methods will have to be developed to insure that the trainees acquire the necessary information.

Table 8. **Distribution of Sample Readability Levels**
(Inventory Management)

Readability (RGL)	Number of Samples	Percent	Cumulative %
12-12.9	9	32	32
11-11.9	12	42.8	74.8
10-10.9	3	10.7	85.5
9- 9.9	4	14.5	100

$N = 28$

Mean Readability Level	= 11.4
75 Percent Decision Rule	= 12.1
Madden and Tupes Reading Rq Est	= 10.6

It was possible in the IM course to obtain data on student performance in the form of final course grades. This was done in order to determine the correlation between a student's RGL and a measure of his performance in the IM course. The correlation between RGLs and final course grades was low ($r = 0.26$) and nonsignificant ($p = 0.11$) which should not be interpreted as meaning that reading skills are unimportant in the course, but rather that alternative means of instruction in the course probably helped get the information to the student in one form or another. To clarify this point, Lautman *et al.*, (1973) conducted an experiment in which the readability of study guide material in the Material Facilities Specialist Training Course was lowered between 3 1/2 and 5 RGLs as measured by the ARI, and 1/2 - 2 1/2 RGLs as measured by FORCAST. The simplification of the modified study guides was accomplished by: (1) using shorter words, (2) shorter sentences, (3) avoiding "complicated" sentence construction, (4) personalizing the material by use of personal words and personalized sentences, (5) use of the active instead of the passive voice, (6) revision of tables, and (7) presenting information in a stepwise manner. Despite all this effort, the modified study guides did not yield significantly better performance than the original ones. This was somewhat surprising, but analysis of a typical Air Force classroom revealed multiple sources of information presention; e.g., lecture, performance, fellow students, audio-visual aids, remedial sessions, etc., such that a trainee unable to read training materials could obtain the relevant course information from other sources.

Tables 9 and 10 present the data obtained from the PME course. The PME course is very demanding which is reflected by the high Elec AQE (80) selector AI. The mean UAT III RGL for the trainees was 12, as compared with an estimate of 12.7 by M-T and 11.8 by the Caylor formula. Since the UAT III has an upper limit of 12.9, there may have been a "ceiling" effect on the reading scores which is reflected by the skewed distribution in Table 9. The reading requirement level of the course using the 75 DR was estimated

Table 9. **Distribution of Trainee RGLs**
(Precision Measurement Specialist 3ABR 32430-2)

RGL	Number of Trainees	Percent	Cumulative %
12.9	12	14	14
12.5	21	25	39
12.2	17	20	59
11.9	10	12	71
11.7	10	12	83
11.6	3	4	87
11.2	4	5	92
10.8	3	3	95
9.9	3	4	99
9.2	1	1	100

$N = 84$

UAT III Mean	= 12.0, s.d.	= .71
Madden and Tupes Mean Est	= 12.7, s.d.	= .93
Caylor Mean Est	= 11.8, s.d.	= .81

Selector AI, Elec AQE - 80

to be 11.6, compared with the 12.5 (Gen AQE was estimated by averaging trainee Gen AQE scores) estimate using the M-T formula. The high M-T's reading requirement estimate reflects the high qualifications necessary for success in the course. It should be noted that the 75 DR of 11.6 was surpassed by 84 percent of the trainees tested in the PME course.

As in the IM course, it was possible in the PME course to obtain performance data on some of the trainees in the form of final course grades and course completion rates, since parts of PME are self-paced. Since the average RGL of a student in the course exceeded the 75 DR reading requirement level, it was not expected that a trainee's RGL would correlate highly with final course grades or completion times and, in fact, this was true, The correlations were 0.12 and -0.14, respectively, (N = 37) both of which are

Table 10. **Distribution of Sample Readability Levels**

Readability (RGL)	Number of Samples	Percent	Cumulative %
13+	1	1.6	1.6
12-12.9	7	11.6	13.2
11-11.9	25	44.6	54.8
10-10.9	22	36.6	91.4
9- 9.9	5	8.6	100

$N = 60$

Mean Readability Level	= 11.1
75 Percent Decision Rule	= 11.6
Madden and Tupes Reading Rq Est	= 12.5

nonsignificant. Almost all of the trainees in PME had the requisite reading skills such that their differential performance was affected more by such skills as math skills. Correlations between scores on a math attitude test and course grades and completion times were 0.47 and -0.72, respectively.

Table 11 summarizes the reading requirement levels for the 5 courses. The 75 DR is the most valid estimate since it is based on actual reading materials from the courses; therefore, it is interesting to compare this figure with the mean RGLs of students in the courses to obtain an estimate of the "gap" between literacy skills and requirements and, hence, of the training problems that might result. It is somewhat amazing that the two courses (WM and IM) having the lowest selector AIs, and also the lowest average RGLs, had the highest reading requirement of 12.1. The mean RGLs of trainees in the remaining three courses all exceeded their reading requirement levels. The use of the Madden and Tupe's formulas to estimate reading requirements must be done with caution, since these estimates are obtained from the appropriate selector AIs. A more meaningful procedure would be to determine the reading requirement of a course using a decision rule like the 75 DR, and then adjust the AQE selector AIs until this requirement is satisfied. Of course, this procedure may not always be possible due to changing student input.

Table 11. **Reading Requirement Levels of the Technical Courses**

Course	UAT III Mean	75% Decision Rule	Madden and Tupes Reading Rq Estimate
NWS	11.8	11.3	11.4
WM	10.7	12.1	9.6
ME	12.1	11.5	11.3
IM	11.3	12.1	10.6
PME	12.0	11.6	12.5

Table 12 summarizes the average reading ability levels for students in the 5 courses. In this case, the M-T's formulas, using AQE data, served as excellent predictors of the actual tested RGLs. Deviations from the UAT III mean range from 0 to only 0.7. The Caylor estimates, however, were more erratic ranging from -0.2 to -1.6 and consistently underestimated students' tested RGL. It is,therefore, suggested that the M-T formulas be used if an estimate of the trainees' average RGL is desired for a career field.

Table 12. **Comparison Between Madden and Tupes and Caylor Average RGL Estimates for the Technical Courses**

Course	UAT III Mean	M-T Mean Est	Deviation	Caylor Mean Est	Deviation
NWS	11.8	12.2	+0.4	11.6	−0.2
WM	10.7	10.7	0	9.9	−0.8
ME	12.1	*	-	*	-
IM	11.3	11.3	0	9.7	−1.6
PME	12.0	12.7	+0.7	11.8	−0.2

*Data not available.

Applications to Air Force Career Fields and Conclusions

The literacy skills and reading requirement methodology, described in the previous section, was relatively simple and straightforward and it could be applied quite easily to entire Air Force career fields. The biggest problem that would have to be dealt with would be in specifying those reading materials crucial to job success in a specific career field. Actually, this could be accomplished by referring to Air Force specifications, asking supervisors, job incumbents, or through a task analysis. Of course, if OJT reading requirements were being investigated, the CDCs themselves would serve as the source of reading samples.

Once the representative sample of reading materials has been collected, it is an easy matter to determine readability. This present investigation used the FORCAST formula because it appears to have the greatest potential for use in the field, however, the ARI would definitely be preferable at those locations where reading materials are actually being produced, since it is completely automated and a secretary could do the necessary calculations. It should be noted that the 75 percent Decision Rule may be too low in those instances where an instructor is not present. For example, although Lautman *et al.*, (1973) found no significant performance differences with simplified course study guides there were significant performance differences when CDCs were simplified using the same procedures. Obviously, in the field, the trainee is limited in his sources of information. What decision rule should be used with CDCs can be an arbitrary decision, or preferably decided through empirical investigation.

Table 12 indicates that the problem of determining the average trainee RGL in a career field can be accomplished quite easily by using the appropriate Madden and Tupes regression equation with the mean AQE data of the personnel in the field. Those equations are as follows,

Career Fields for which the selector AI is administrative

RGL = .0437 Gen AI + .0501 Ad AI + 5.0730

Career Fields for which the selector AI is Mechanical

RGL = .0991 Gen AI - .0085 Mech AI + 5.0459

Career Fields for which the selector AI is Electronics

RGL = .0743 Gen AI + .0222 El AI + 4.6088

and the necessary AQE data is available on the Airman's Form 156. With the completion of this step the reading skills of an Air Force Career ladder can be established. Whether or not this is a necessary procedure for all fields (and alternatives for dealing with reading problems) will be discussed in the following section.

Recommendations for Dealing with Reading Problems in the Air Force

The methodology, described in the previous sections, for determining the reading skills and requirements of Air Force career ladders is a straightforward approach, which has several possible applications. First of all, it would be valuable to know what the reading requirement of a technical course or career field is in order to compare it with the reading abilities of the personnel in the field. If there is a discrepancy, or "literacy gap" which is large, it may pose special training problems and result in increased washback rates, remedial sessions, CDC failures, etc. Also, if Air Force decision makers are considering

lowering the selector AIs for a career field, it would be useful information to know how such changes will affect the average RGL of the personnel in the field. If selector AI changes were to significantly increase the size of the "literacy gap," then special training provisions would have to be made in order to insure that the trainees were able to acquire the necessary information for successful job performance. A reading requirement level established for a technical area could also be used as a selection index in addition to such standardized scores as AQEs and AFQT; however, it is questionable whether this is a necessary or even desirable step. For example, the AQE selector AIs, if properly established, adequately account for the reading requirement of a technical course (Table 11, the NWS, ME, and PME courses). Therefore, it is unnecessary to establish independent reading requirement selectors when changes in the AQE selector AIs would accomplish the same purpose.

The next question which arises is how this methodology should be applied to the hundreds of career ladders in the Air Force. Undoubtedly, those career ladders experiencing training difficulties or poor job proficiency should be investigated first, in order to determine if a "literacy gap" might be the causal factor. Other career ladders not experiencing unusual difficulties might also be investigated because extremely high readability requirements might exist, yet be compensated for by increased training times and costs. There is no obvious reason, for example, why the WM and IM courses' reading requirements (Table 11) should be higher than PME's which is more technical and requires higher average educational levels. Also, in reference to the OJT system, adequate job performance does not negate the existence of a literacy gap. For example, Vineberg, Sticht, Taylor and Caylor (1971) found that after 30 months on the job, 90 percent of the job incumbents performed at the uppermost levels of the performance distribution, however, any training system that requires 30 months to develop proficient workers can hardly be called cost effective.

Given that a "literacy gap" is discovered in a career field, there are several general strategies that can be pursued to reduce the gap. The least expensive and most expedient approach involves the establishment of stringent enough selector AIs to eliminate those who cannot perform. Although this approach seems simple enough, there are important ramifications which follow. For one thing, AQEs and AFQT are adequate when used with large numbers of personnel, however, like any other selection device, their "error" may be acceptable to decision makers but earth-shattering to an airman who is part of that "error" and, thus, denied the opportunity to pursue his desired field of work. Even if one disregards the humanistic aspects of the selection approach, there are practical implications as well. Certain career fields will contain the bulk of the poor readers, resulting in undesirable effects on the entire career ladder and creating future training difficulties that will result when personnel with inadequate reading abilities move to supervisory positions, or enter into cross-training. Finally, selection is a possibility only when the educational levels of incoming manpower remain high enough. The situation may occur when available manpower will have to be trained even though a career ladder's entry requirements are not being met.

This leads naturally to the most commonly used approach for reducing the literacy gap, and that is literacy training programs. The improvement of literacy skills is an immense and complicated problem which offers no easy solution. It is illogical to assume that the military can radically alter the reading skills and habits of men in 12 weeks, when 12 years of public schooling could not do it, but the military has accepted its responsibility to improve the educational skills of its men, and all the services have had reading improvement programs at one point or another with generally mediocre results. One reason for this is that the military has set RGL goals too low to affect job performance. The literacy programs in the Air Force, Army, and Navy have set objectives of 6th, 5th, and 5th grade, respectively, but even with such limited goals the success rates have been unimpressive, 60 percent achieved the sixth grade for the Air Force, and 76 percent achieved the fifth grade criterion for both the Army and the Navy (McGaff, 1973). Probably one of the most disturbing facts about those trainees, who participated in the reading programs, is that 43 percent of them had graduated from high school. Reading improvement has a place in the military training environment, but it is questionable that it should be a one-shot affair in basic training. The most viable approach appears to be a systems approach (Suggested by Tom Sticht in personal communication) whereby a man deficient in reading skills obtains job-related reading training in basic training, followed by base education supervised reading improvement programs which have the capability of operating over a longer period of time and would, therefore, be more productive and beneficial to the individual. The purpose of job-related reading programs in basic training would be to teach the individual those job-related reading skills necessary for successful job performance. It is also hoped that the use of job-related reading materials in a course would motivated the student because in a very real sense, he would actually be training for his future Air Force job.

The next logical alternative for reducing the "literacy gap" would be to modify or simplify the job reading materials until they are in close agreement with the reading skills of personnel in a career ladder. In the long run, this is probably the most practical approach to follow but it is not without its disadvantages. For one thing, it is a massive task which may have only limited results (Lautman *et al.*, 1973). Also, as a practical factor, there is a level (readability) below which technical materials cannot be rewritten, and any further attempts to do so may actually impede learning. On the other hand, although Air Force technical writers may be experts in their field, they may also be ineffective writers and the establishment of a writing course may not be a bad idea.

Within the general context of material modification, the design and use of Job Performance Aids (JPAs) can be included. Although JPAs were initially intended to improve job proficiency, they can also be classified as a "job reading aid" since they provide a person with meaningful information. A JPA itself, is defined as "any information storage device, such as a manual, checklist, or diagram, which is available to assist a man in doing his job." (Sticht *et al.*, 1971, p. 34). The principle underlying their development is that they are designed with specific cues to provide maximum retrievability of information to a man using them to perform a job. With an emphasis on improving reading comprehension, such things as readability, vocabulary, formats, sequencing of information, different aptitude groups, etc. would have to be considered in the design of JPAs as reading aids.

The final alternative that will be discussed for dealing with inadequate reading skill involves alternative means of presenting information to a trainee. Specifically, the possibility exists that within limits people may be able to learn better by listening than by reading. For example, Sticht *et al.*, (1971) discovered that listening ability was related to job proficiency when measured by job knowledge or job sample performance tests. Also Sticht (1971) found that 45 percent of a group of men with poor reading abilities preferred to learn by listening rather than reading. However, he also found that 86 percent of the good readers preferred reading to listening, therefore, presenting information auditorily would have to be done with caution and with limited types of information.

Of the different approaches discussed for dealing with reading problems in the Air Force, it is not necessary to select one and pursue it while ignoring the others. All of them are applicable in different contexts, but it is important to remember that there are significant differences between career fields in terms of reading requirements, trainee qualifications, and content of the training literature. Therefore, any effort designed to reduce a literacy gap would have to take into consideration those characteristics unique to the particular career field experiencing reading problems.

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